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PENSOFT

First record of *Phragmatopoma caudata* Krøyer in Mörch, 1863 (Annelida, Sabellariidae) in the state of Piauí, northern Brazilian coast: westernmost record in Brazil

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Abstract
We report the first occurrence of *Phragmatopoma caudata* Krøyer in Mörch, 1863 in Piauí state, Brazil. This is the first record of this species in the APA Delta do Parnaíba, a national environmental protection area that comprises areas from 3 Brazilian states, Maranhão, Piauí and Ceará. This is also the northernmost and westernmost record of this species in Brazil to date, further extending by 415 km its known distribution in Brazil, and helping to fill a gap on the knowledge of its distribution in South America.

Key words
Polychaeta; Sabellida; reef-building polychaete; new record; extension range; Delta do Parnaíba.

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Introduction

The coastline of the state of Piauí is 66 km long, and despite being the shortest coastline among the Brazilian states (Fig. 1), it is characterized by a wide variety of natural environments such as mangroves, dunes, lagoons, granitic and sandstone rocky outcrops, estuaries and deltas. These different environments, and the interplay between them, probably contribute to a high local biodiversity, although few efforts have been made to survey Piauí's marine invertebrate fauna. As a result, the coastline of Piauí is an area where there is still a great uncertainty regarding the richness and composition of marine species, although all its extension is included within a national environmental protection area, the Delta do Parnaíba Environmental Protection Area (APA Delta do Parnaíba) (Fig. 2).

Phragmatopoma caudata Krøyer *in* Mörch, 1863 belongs to the family Sabellariidae Johnston, 1865, and like many species from this family is a reef-building species. Reef-building polychaetes, like other bioconstructing species, are able to increase heterogeneity of the substrata, generating new habitats, and thus contributing to biodiversity (Jones et al. 1994, Goldberg 2013). Observations on increases in taxonomic diversity and on reef associated species in Brazil and elsewhere have

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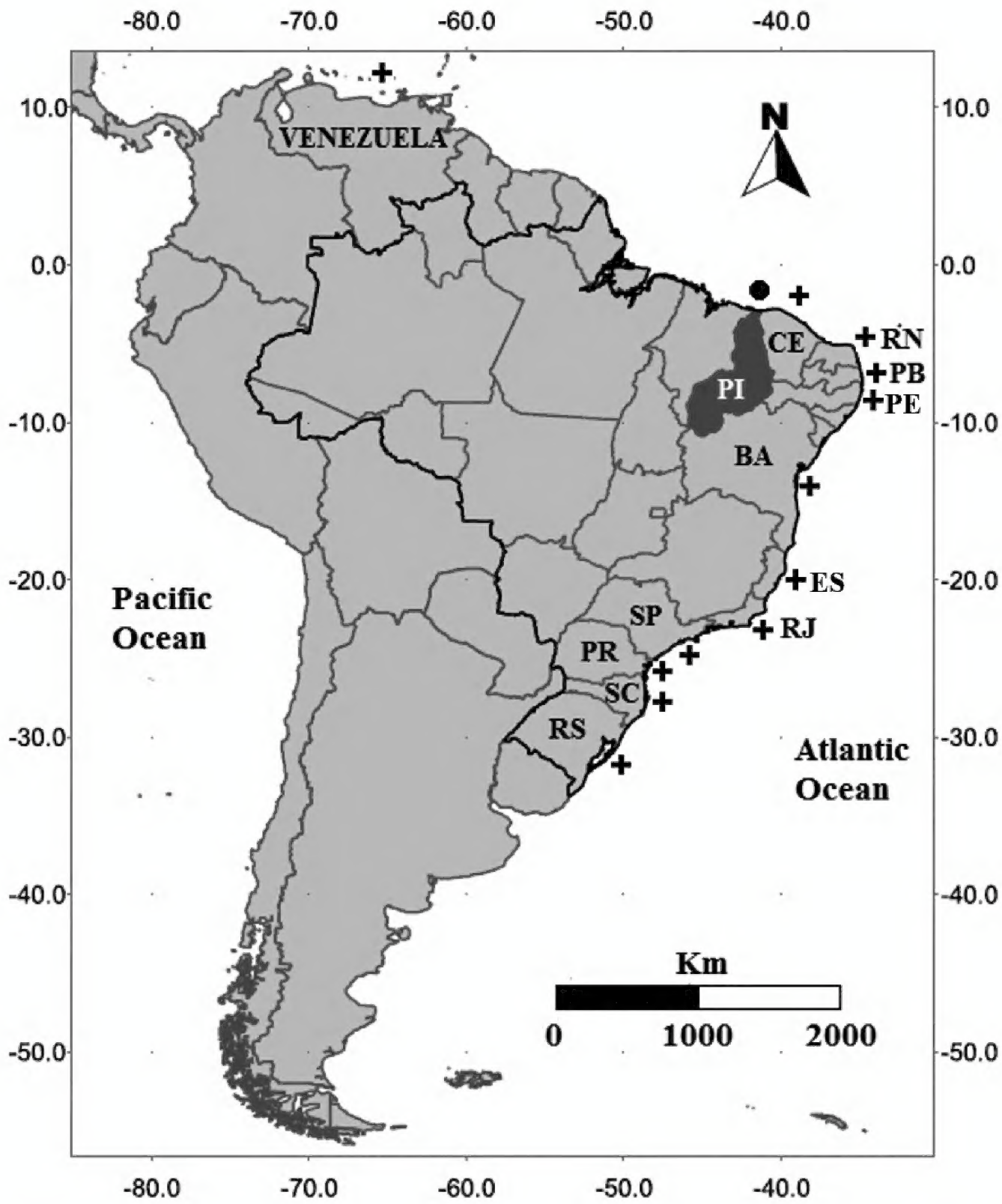


Figure 1. Records of *Phragmatopoma caudata* in Brazilian states and the nearest westward record. (+) Previous records. Venezuela: Ilhas Tortuga e Ilhas Margarita (Kirtley 1994). Brazil: Ceará-CE (Fausto-Filho and Furtado 1970, Kirtley 1994, Fournier et al. 2010; Nunes et al. 2016), Rio Grande do Norte-RN (Fournier et al. 2010), Paraíba-PB (Fournier et al. 2010, Santos et al. 2011), Pernambuco-PE (Nunes et al. 2016), Bahia-BA (Santa-Isabel et al. 2000), Espírito Santo-ES (Nunes et al. 2016), Rio de Janeiro-RJ (Amaral 1987, Kirtley 1994, Lana and Bremec 1994, Moreno and Rocha 2006, Masi and Zalmon 2008, Masi et al. 2009, Occhioni et al. 2009, Fournier et al. 2010), São Paulo-SP (Amaral 1987, Morgado and Amaral 1989, Lana and Bremec 1994, Rocha 1995, Micheletti-Flores and Negreiros-Fransozo 1999, Fransozo et al. 2000, Occhioni et al. 2009, Fournier et al. 2010, Nunes et al. 2016), Paraná-PR (Lana and Bremec 1994, Bosa and Masunari 2002a, 2002b, Occhioni et al. 2009, Fournier et al. 2010, Nunes et al. 2016), Santa Catarina-SC (Kirtley 1994, Lana and Bremec 1994, Fournier et al. 2010) and Rio Grande do Sul-RS (Amaral 1987, Lana and Bremec 1994). (●) New record. Letters correspond to Brazilian states abbreviations.

provided evidence of the role of sabellariid reefs in supporting high levels of diversity (Micheletti-Flores and Negreiros-Fransozo 1999, Bosa and Masunari 2002a, 2002b, Dubois et al. 2002, 2006, Dias and Paula 2001, Sepúlveda et al. 2003, Pholer 2004, Ataide et al. 2014). It is likely that *P. caudata* reefs contribute to invertebrate diversity in rocky areas of the APA Delta do Parnaíba, and therefore it is important to register and monitor local occurrence and abundances of this species.

Regarding other polychaete species, 5 belonging to 2 families were previously recorded at the APA Delta do Parnaíba. *Laeonereis culveri* (Webster, 1879) (Pamplin et al. 2007), *Alitta succinea* (Leuckart, 1847) and *Perinereis anderssoni* Kinberg, 1866 (Santos and Steiner 2006) and *Nereis riisei* Grube, 1857 (Santos and Lana 2003) belonging to the family Nereididae Blainville, 1818; and *Chloeia viridis* Schmarda, 1861 (Amaral and Nonato 1994) belonging to the family Amphinomidae Lamarck, 1818.

The world known distribution of *P. caudata* is restricted

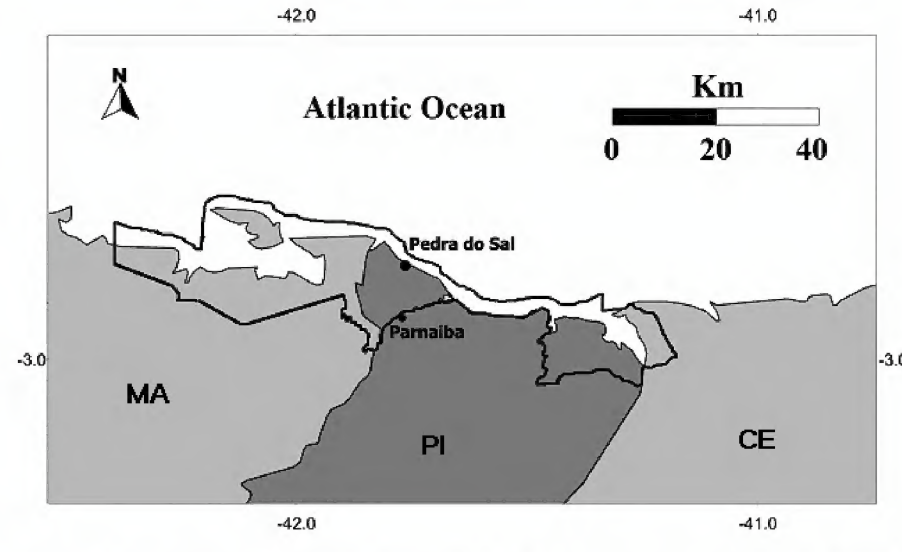


Figure 2. Location of Pedra do Sal Beach, in Piauí (02°48′13″ S, 041°43′48″W), and limits of the APA Delta do Parnaíba.

Figure 3. *Phragmatopoma caudata* at Pedra do Sal Beach, Parnaíba, Brazil.

to the Western Atlantic and extends from Brazil to Florida, including locations in Venezuela, the Caribean, Mexico and Texas (Kirtley 1994). The type locality is the Caribbean, but the exact location is unknown (Kirtley 1994). *Phragmatopoma lapidosa* Kinberg, 1867 is the main synonym of *P. caudata* as suggested by Kirtley (1994) and confirmed by molecular data (Nunes et al. 2016). The later work also provide evidence for the existence of genetic connectivity among populations across the whole distribution range of the species, and emphasizes the importance of new records of this species along this range in order to fill the gaps on its distribution knowledge and to confirm or deny the existence of discontinuities within its geographic limits (Nunes et. al. 2016).

The present study reports the first record of *Phragmatopoma caudata* off the coast of the Piauí and gives detailed information on the morphology and characters used in its identification; the new data extend the known geographic distribution of this species in Brazil and improves the knowledge of the fauna of the APA Delta do Parnaíba. The coastline distance that separates the closest known record of the species in the country, in Fortaleza-Ceará (Fausto-Filho and Furtado 1970, Kirtley 1994), from the new record reported here is of approximately 415 km.

Methods

Sand reefs of *Phragmatopoma caudata* were first noticed in December 2010 (Fig. 3) at Pedra do Sal beach (02°48′ 13″ S, 041°43′48″ W), municipality of Parnaíba, Brazil (Fig. 2). In April 2011 those reefs were studied in more details as follows.

Colonies were found on granitic natural substrata, in the intertidal region of Pedra do Sal beach. With the aid of a chisel and a mallet, 5 cubes of about 0.1 m edge (0.001 m^3) were taken from random colonies. Subsequently, each cube was broken into smaller pieces and the individuals found were collected and fixed in 4% formaldehyde. In laboratory, 4% formaldehyde was replaced by 70% ethanol. With the aid of needles, scalpels, and a microscope, some individuals were examined and their morphology was observed. The opercular structure of some individuals was dissected to expose the opercular paleae (outer, middle and inner), due to the necessity of observing their shape and relative position to assure species identification, following Kirtley (1994). Thirty individuals were examined in total, including individuals that were left intact and the ones that were dissected.

After collection and identification, 16 individuals used for identifications to serve as voucher specimens were deposited in 2 scientific collections in Brazil, Coleção do Instituto de Biologia da Universidade Federal do Rio de Janeiro (UFRJ) and Museu Nacional do Rio de Janeiro. These specimens are settled under the numbers IBUFRJ 3580 and IBUFRJ 3588. Fifty individuals were fixed in 98% ethanol for future molecular analysis.

Results

Thirty specimens were examined, with average length of 19 mm (min. 16 mm; max. 23 mm) (Fig. 4). The operculum presents paddle-shaped outer paleae slightly larger than 1 mm long, with plume-shaped appendage on top (Fig. 5); these paleae surround the whole opercular crown circumference (Fig. 6). The middle paleae are arranged radially, forming the opercular cone completely hiding the row of inner paleae (Fig. 6). The middle paleae are formed by two teeth that give them an uncinate shape; the superior tooth is approximately 3 times longer than the inferior one, with a pronounced downward curvature distally (Fig. 7). The inner paleae (Fig. 8) are inferior to the middle paleae (Fig. 9) and very similar to them, except by the relatively less robust shape and by a distal bifurcation formed by its 2 teeth, which have the same length.

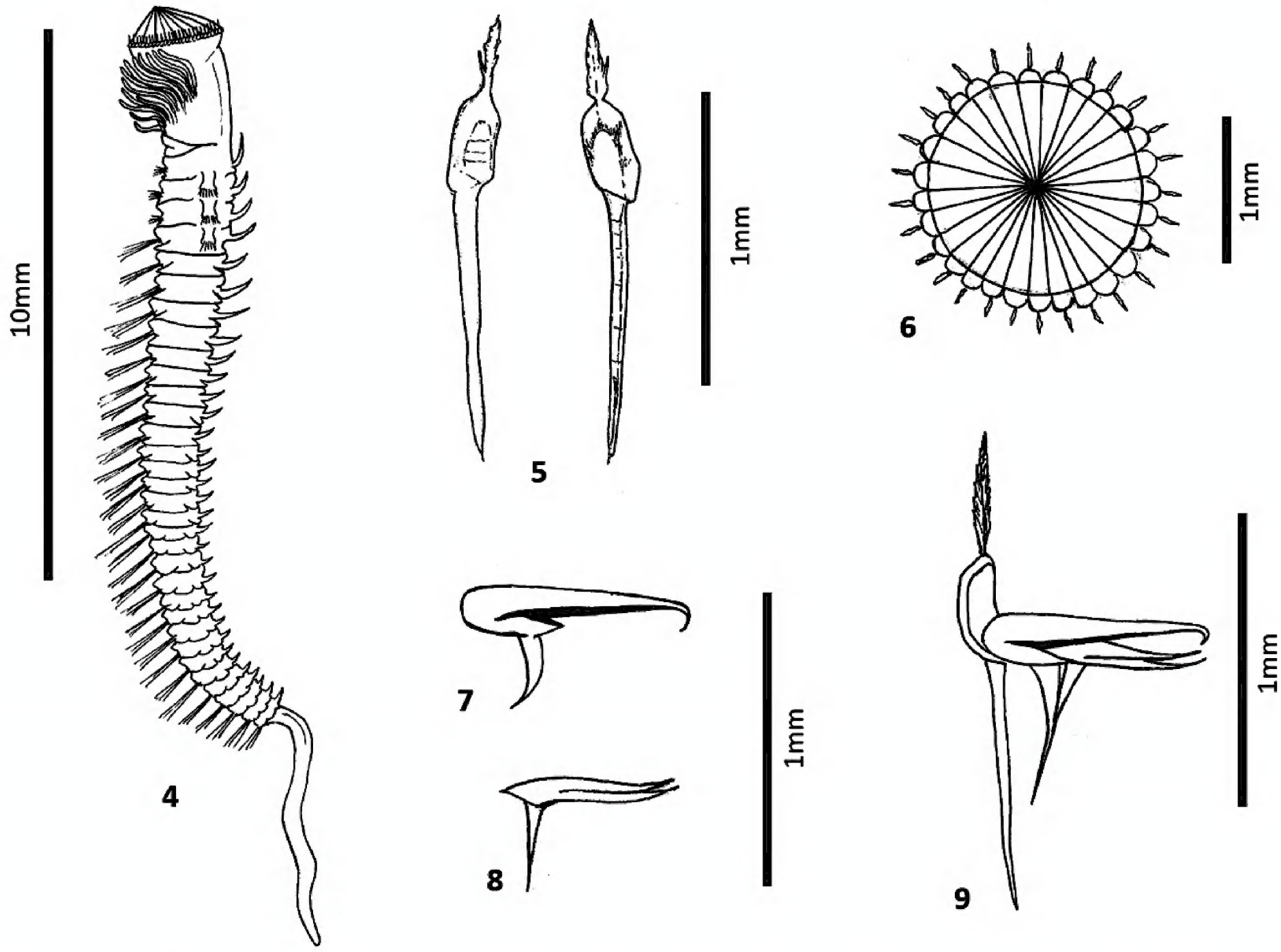
Discussion

The material of *Phragmatopoma caudata* examined here does not differ from descriptions of this species from other localities (Kinberg 1867, Amaral 1987, Kirtley 1994).

This work reports for the first time the occurrence of *Phragmatopoma caudata* on the coast of the state of Piauí. Previous records show that the species has a wide distribution in Brazil, occurring from the state of Rio Grande do Sul to the state of Ceará, and that the nearest record to the west is in Venezuela (Fig. 1). The species also occurs in several locations in the Caribbean and in the Gulf of Mexico up to Florida (Kirtley 1994).

This work, therefore, extends the known distribution of this species across the Brazilian coast, becoming the westernmost record of *P. caudata* in the country (Fig. 1). It is also only the second location where the species is recorded in Brazil's northern coastline, after Kirtley (1994), Fausto-Filho and Furtado (1970) and Fournier et al. (2010) had recorded it for Fortaleza, Ceará (Fig. 1).

Fournier et al. (2010) examined the inter- and intraspecific variability on chemical composition of biocement among sand-reef-building polychaetes, including Brazil-



Figures 4–9. Adult of *Phragmatopoma caudata* from Pedra do Sal, Parnaíba. **4.** Entire animal. **5.** Lateral views of the outer palea. **6.** Upper view of the opercular crown. **7.** Middle palea. **8.** Inner palea. **9.** Relative position of paleae in association to form one of the sections of the opercular crown circumference.

ian populations previously recorded as *P. caudata* or *P. lapidosa* Kinberg 1867 from the following states: Santa Catarina, Paraná, São Paulo, Rio de Janeiro, Paraíba, Rio Grande do Norte and Ceará. These authors concluded that there is some degree of variation on the cement's biochemistry among populations. Another work (Faroni-Perez and Zara 2014) acknowledged differences on physiological and morphometric reproductive traits between Brazilian and Florida populations of *P. caudata*, particularly on oogenesis and oocyte development. Although these works revealed the existence of phenotypic variations among populations of *P. caudata* along its distribution, which could indicate intraspecific variation or possibly speciation, they did not deal with taxonomic relationships among *Phragmatopoma* spp. or with genetic connectivity between *P. caudata* populations.

Recent published data (Nunes et al. 2016) from DNA analysis pointed that populations found along the Brazilian coast, as well as those found in the rest of South America, up to Florida, and including the Caribbean Sea, are representatives of a single species (*P. caudata*), as previously suggested by Kirtley (1994). Therefore, *P. lapidosa* is a synonym of *P. caudata* as inferred by both morphological (Kirtley 1994) and molecular data (Drake et al. 2007, Nunes et al. 2016). It was also shown that populations across the Brazilian coastline and the Caribbean have a strong genetic connection and do not show population structure. This result indicates that this species is able to overcome the major geographic barriers along South and Central American Atlantic coasts, although this does not discard the existence of areas where the species is absent. The occurrence of *P. caudata* in the state of Piauí is in accordance with the species dispersive ability.

This study therefore contributes to fill the distribution gap of this species observed in the northern coast of Brazil, although the blank on distribution persists between this new record and the nearest records to the west, which are from Tortuga Island and Margarita Island in Venezuela (Kirtley 1994) (Fig. 1). In addition, this is the first record of *P. caudata* in the APA Delta do Parnaíba, increasing the knowledge on the local biota and the ability of environmental agencies to manage this important marine reserve in the Brazilian northeastern coast.

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Authors' Contributions

JGFGF collected the material, JGGF, MVQBS and RAS identified the material, JGGF made the drawings, JGGF, MVQBS and RAS wrote the text.

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